The Phantom Torso

An unusual space traveler named Fred is orbiting Earth aboard the International Space Station. His job? To keep astronauts safe from space radiation.

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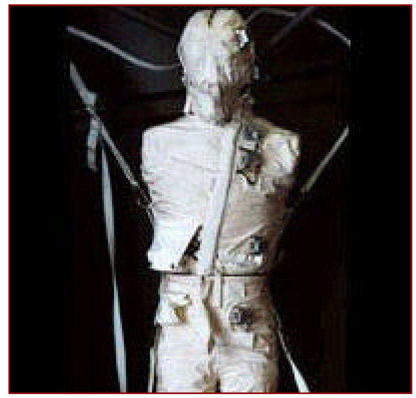


May 4, 2001 -- Fred has no arms. He has no legs. His job is keeping astronauts safe.

Fred is the Phantom Torso, an approximately 95-pound, 3 foot high mockup of a human upper body. Beneath Fred's artificial skin are real bones. Fred's organs -- the heart, brain, thyroid, colon and so on -- are made of a special plastic that matches as closely as possible the density of human tissue.

Right: The Phantom Torso, also known as "Fred," is an anatomical model of a human torso and head. Fred contains hundreds of radiation monitoring devices. [more information]

Fred, who's spending the next four months on board the International Space Station (ISS), will measure the amount of radiation to which astronauts are exposed. High-energy particles that pass through the human body can disrupt the way cells function. Although no astronaut has ever been diagnosed with space radiation sickness, excessive exposure could lead to health problems.

"We believe the current dose [of radiation to the crew of the ISS] is too small to be of concern," says Dr. Gautam Badhwar, the study's principal investigator at the Johnson Space Center. "The one possibility for radiation sickness might be an EVA situation during a solar event, if perhaps a crew member couldn't be brought back inside safely." But there's still lots to learn, he added, and that's where Fred can help.

The Phantom Torso is designed to do three things, explains Badhwar. First, it will determine the distribution of radiation doses inside the human body at various tissues and organs. Second, it will provide a way to correlate these doses to measurements made on the skin. "In the past we've typically recorded doses *only* on the skin," explains Badhwar, "whereas the risk to crew members is established by exposure to internal organs." Finally, the Phantom will help check the accuracy of models that predict how radiation moves through the body.

Three types of radiation can endanger astronauts in space.

The most energetic are Galactic Cosmic Rays (GCRs) -- the nuclei of atoms accelerated by supernova explosions outside our solar system. Cosmic ray nuclei can be as light as hydrogen, as heavy as iron, or almost anything in between. Because they lack their surrounding coat of negatively-charged electrons, GCRs are positively charged. The heavier nuclei carry the greatest charge, explains Badhwar. "As the charge increases, the amount of energy that the particle can deposit in tissue increases as well."

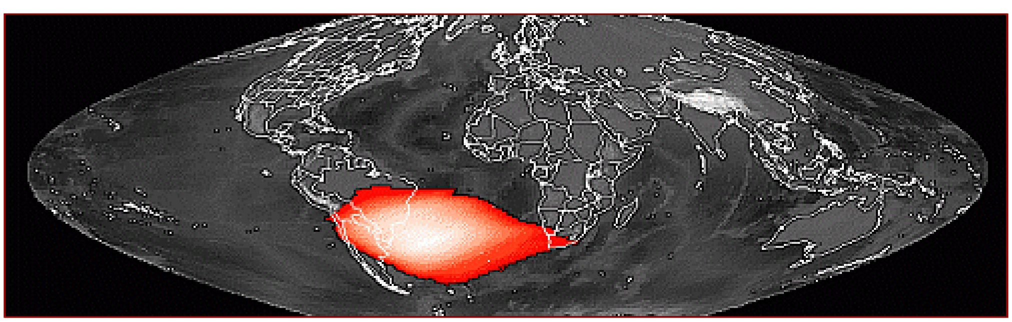
Left: Supernova explosions like this one accelerate atomic nuclei to nearly light speed. The resulting "cosmic rays" pose a potential hazard to astronauts. [more information]

The other forms of particulate radiation consist mostly of protons. Most high-energy protons in the solar system come from the Sun. Although their charge is not great and they are less energetic than GCRs, solar protons can still be dangerous when they come in intense bursts known as solar flares.

The third kind of radiation, which surrounds Earth in areas known as Van Allen belts, consist mostly of decayed products from galactic cosmic ray interactions that have been trapped by Earth's magnetic field.

Some of this trapped radiation is confined to a region above the coast of Brazil, known as the South Atlantic Anomaly. "The Space Station goes through that Anomaly roughly five times a day," says Badhwar. The passage takes, at most, 22 or 23 minutes. That's good, he says.

"If you go through the trapped radiation belt in less than twenty minutes or so, then for the next seventy minutes the body has time to do some repair to the damage done by the radiation." The radiation from solar flares can actually do more harm, he says, simply because it comes at a rate that doesn't give the body time to recover.



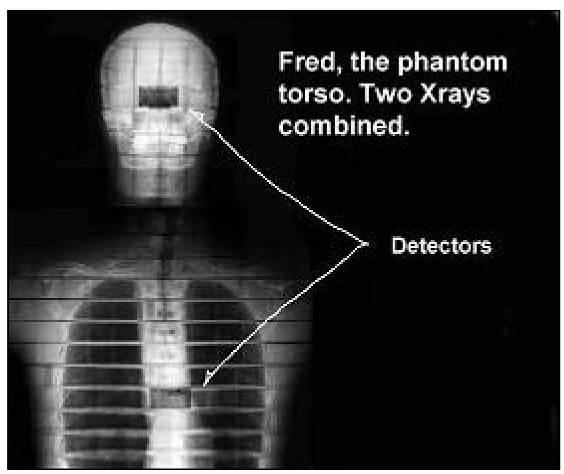
Above: The "South Atlantic Anomaly" is an area of trapped radiation located over the east coast of Brazil. [more information]

In order to measure space radiation as it propagates through Fred's body, Badhwar and his team have sliced Fred horizontally into 35 one-inch layers. In each section they've made holes for radiation detectors called dosimeters. The torso carries 416 lithium-crystal based passive dosimeters, which simply record the total radiation dose received throughout the mission. Fred is also equipped with 5 active detectors. These, placed at the Phantom's brain, thyroid, heart, colon, and stomach, can track the times that the radiation exposures took place.

"With the active detectors, we can correlate the time the radiation was received with the position of the spacecraft," explains Badhwar. "We can separate out quite reliably when we were in the Anomaly and when we were in the Galactic Cosmic Ray region." This kind of split makes radiation models derived from such data applicable to interplanetary missions, too. To assess astronaut exposure on a trip to Mars, for example, "we'll just switch off the Van Allen Belt particles," says Badhwar.

Radiation models devised by Badhwar and colleagues will be able to estimate how much radiation reaches an astronaut's internal organs simply by looking at the dose on his or her skin. That's important, because while the permissible radiation limits are based on internal exposures, practically speaking, all that can be measured is what occurs on the skin.

Right: The Phantom Torso consists of 35 sliced "sections" housed in a Nomex suit. [more information]



Such models are also scalable. Rather than giving a blanket risk assessment for all crew members, they can be customized to each individual in terms of height, weight, and even personal histories: how the astronaut flies an aircraft, or what medical tests he or she might have taken. All this contributes, says Badhwar, to total radiation exposure.

Even our internal bacteria rate a careful look: If a crew member gets too much radiation, it could kill the digestive bacteria essential for breaking down food.

Space station crew members will be sending data from the Phantom's five active dosimeters back to Earth about every ten days. When the device returns to Earth next fall, Badhwar and his team will be able to examine results from Fred's passive detectors as well.

"The thing that we're really going after is to get as good a handle as we can on what the organ exposures really are." he says. The goal is to make sure that the crew is exposed to the least amount of radiation possible.

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Web Links

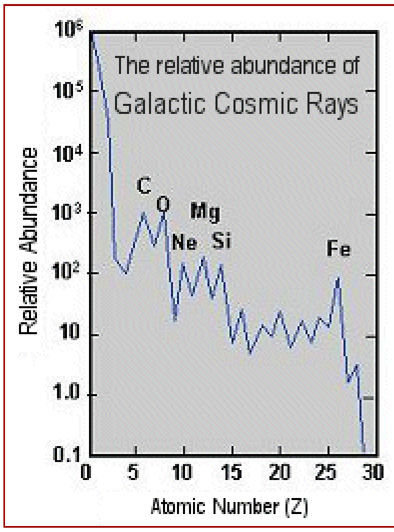
Space Radiation: Effects on Humans -- from the National Space Biomedical Research Institute

Ionizing Radiation in Space -- the basics, from the NASA/MSFC Space Environment & Effects Group

The Phantom Torso Fact Sheet -- from the NASA Marshall Space Flight Center newsroom

Galactic Cosmic Rays -- Galactic cosmic rays (GCRs) come from outside the solar system but generally from within our Milky Way galaxy. Find out more at this site from NASA/Goddard.

ISS Radiation Experiments -- Three radiation experiments are underway on the International Space Station.



Right: Galactic Cosmic Rays consist of many elements, but the lighter nuclei dominate. Heavier nuclei carry a greater charge and are more damaging to human tissue. [more information]

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